FLEX

Facility for Low Energy eXperiments in Buildings

FLEX for HVAC – Use Case

Can industry increase the effectiveness of low-capacity, low-energy cooling systems for both retrofit and new construction applications?

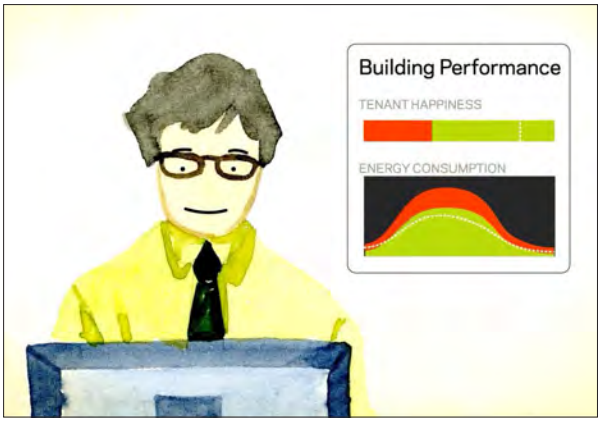
The Challenge

Radiant cooling, chilled beams, displacement ventilation, and UFAD systems pose tremendous potential to lower cooling energy use and deliver thermal comfort. However, adoption of these technologies has largely been limited to new construction applications in which thermal loads can be lowered and controlled through building envelope and interior lighting designs. These systems' capacity and effectiveness in meeting thermal load and comfort requirements of perimeter spaces is a result of their interactions with the building façade and interior loads from lighting and other devices. Understanding how these elements affect system performance will illuminate opportunities to guide product, system, and controls design, and will improve product effectiveness at meeting load requirements for both retrofit and new construction applications.

For example, it has been understood that convection plays a large role in maximizing the cooling output of radiant panels or slabs. However, interactions and impact of convection that occur in typical buildings (e.g. convective effects from lighting systems and façades) are not well understood. With further insight into thermal performance impacts on radiant cooling, opportunities will emerge to **work synergistically with lighting and façade systems to increase cooling effectiveness** under various operating conditions.

What do designers, engineers, and manufacturers need to develop advanced cooling systems capable of **delivering low-energy cooling solutions, while maintaining indoor environmental comfort** and occupant satisfaction?

FLEX offers a unique opportunity for industry and researchers to collaboratively solve 'stretch' problems of this nature. Consider the challenge of radiant cooling panels and their interactions with convection from various façade types; FLEX provides a path to solutions that cannot be found anywhere else in the world.



Delivering thermal comfort and low energy use.

Testbed Capabilities	Performance Parameters and Benefits
Horizontal and vertical interior surface temperature measurement	Air and radiant temperature distribution of the space, relates to thermal comfort
Room imaging and visualization	Space thermal distributions
Lighting system and fixture power	System energy use, and peak demand; energy savings vs. 1980's base-case in twin cell
Temperature and flow of HVAC utilities	HVAC thermal loads
HVAC energy use	HVAC impacts; whole-building or zone energy savings due to retrofit system
Reconfigurable interior spaces	Create multiple zonal conditions – perimeter and core applications
Reconfigurable glazing	Impact of glazing on convection, thermal loads, radiant cooling output, energy and thermal comfort
Reconfigurable shading	Impact of shading on convection, thermal loads, radiant cooling output, energy and thermal comfort
Robust data acquisition, accommodation of additional instrumentation	Flexibility to integrate experiment-specific measurement with existing testbed sensors
Ability to interoperate and execute control across a variety of platforms and devices	Flexibility to test diverse systems and components, control solutions, and proprietary systems

Starting Point

A manufacturer has a **radiant cooling product** and is interested in evolving its application in the retrofit and new construction markets. The radiant cooling product has been bench-tested, component-tested, and demonstrated in a room environment, isolated from interactions with the wider array of building interior systems and convective sources. It has not yet undergone extensive long-term performance testing for interactions with, and impacts of, convection from various grades of glazing and shading systems, with continuous high-resolution field-measured data.

Solution Pathway

System **performance validation in FLEX's 1980's vintage testbed**, with identical side-by-side test cells.

The manufacturer conducts a field test, leveraging testbed measurement capabilities for energy performance and occupant comfort assessments that were not possible in the manufacturer's in-house facilities.

Immediate Outcomes

- Cooling and convective capacity effects of façades and lighting systems.
- Energy, thermal load and comfort performance metrics.
- Validation of sequences of operations, **system energy savings relative to a base case cell.**
- Holistic archival set of **high-quality field measured data** (dozens of points) for use in manufacturer documentation and publications.
- Comprehensive experimental results and information to adjust system control logic, or component performance, if energy or comfort targets are not met.

Extended Validation & Deployment Opportunities

- Conduct performance tests in **FLEX's rotating testbed** to determine performance under diverse orientations.
- Introduce occupants through **human subjects testing** in the 1980s, 2010, 2013 or net zero testbeds – shift experimental focus to occupant satisfaction and personal control.
- Use the virtual design testbed and simulation tools, like Modelica and Radiance, to develop robust calibrated models; **partner with LBNL researchers with subject matter expertise.**
    - Use field-measured data to extend experimental findings to diverse climates, room **geometries, envelope, and HVAC systems.**
- Work with LBNL researchers to **validate radiant cooling simulation algorithms** for use in annual energy simulation platforms such as EnergyPlus.
- Identify **low-energy controls and operations** strategies.
- Build partnerships with **early-adopter testbed members** to conduct scaled demonstrations in real-world buildings across the nation.
- Use experimental data, in combination with access to **utility/state testbed members** to expose benefits to emerging technology and new incentive programs, and for future code requirements.
- Provide anonymized system design and operational performance data to **members of the AE community** using the virtual design testbed.

References and Further Reading

Bourassa, N, Haves, P, Huang, J. A Computer Simulation Appraisal of Nonresidential Low Energy Cooling Systems in California, LBNL-50677.